

Research Article

Experience-Based Decentralized Marketing and Advertising (Ex-Mad): A Blockchain Framework for Transparent and Fair Digital Campaigns

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Abstract The contemporary digital advertising ecosystem faces critical technical and operational challenges, primarily driven by centralized intermediaries, data opacity, and privacy vulnerabilities. To address these systemic issues, this paper proposes "Ex-Mad," a decentralized architecture leveraging blockchain technology and the Interplanetary File System (IPFS). The proposed framework integrates three core architectural layers: the user entities (advertisers and end-users), the blockchain ledger for immutable transaction recording, and IPFS for distributed content storage. Unlike traditional centralized models, Ex-Mad utilizes smart contracts to automate campaign management and enforce trustless interactions, ensuring verifiable reward distribution based on user contribution without third-party validation. Furthermore, the integration of IPFS optimizes on-chain storage costs by handling large media files off-chain while maintaining data integrity through cryptographic hashes. The system design enhances auditability through a tamper-proof ledger, eliminates single points of failure, and provides a technically robust alternative to current ad-tech intermediaries. This study demonstrates how the proposed architecture improves system efficiency, reliability, and cost-effectiveness in the digital advertising domain.

Keywords: Blockchain Technology, Smart Contracts, IPFS (Interplanetary File System), Distributed Systems, Digital Advertising Architecture

1. INTRODUCTION

Digital advertising has become a crucial marketing tool globally due to the growing demand for online content. Despite the negative impact of the COVID-19 outbreak and companies reducing their marketing budgets during this period, digital ad spending surprisingly increased by 15.9%. In 2020, internet advertising revenues in the United States were \$139.8 billion, which increased by 35.4% in 2021, reaching \$189.3 billion. In 2022, global digital advertising expenditures reached 209.7 billion dollars, with an annual increase of 10.8%. According to predictions, these expenditures are expected to reach an all-time high of US\$ 681 billion in 2023 [1]. Despite high inflation rates and economic uncertainty affecting marketing budgets, there was a significant increase in total revenues throughout 2022[2]. However, the digital advertising industry is becoming increasingly competitive each year due to the emergence of new technologies and methods.

Marketing is not limited to selling products to consumers. Consumers must keep up with these changes by purchasing and improving their relationships with customers in various ways[3]. The digital advertising industry uses trusted intermediaries to connect advertisers with consumers. These intermediaries are the only organizations that disclose the number of downloads and clicks on ads. In this centralized model, advertisers must trust all transactions made by advertising intermediaries[4]. However, there is no guarantee of transparency and honesty in this system. Advertisers also have concerns about fraudulent activities such as click fraud [5].

Intermediaries in the digital advertising industry use personal data and algorithms to match consumers with advertisers more efficiently. The data collected included gender, education, financial status, and browsing history. Additionally, location information can be determined from the user's IP address. Platforms that provide advertising services require users to agree to share their information with third parties in exchange for the service. This gives them the right to share user data. However, this practice has reduced user satisfaction and increased concerns about protecting personal data[6].

Numerous studies in the literature have identified different barriers to fast, complete, accurate, and cost-effective interactions between advertisers and users. For this reason, researchers and experts are constantly working to develop new

models and technologies. The use of blockchain technology, one of the most recent technologies in recent years, has also been investigated. It is suggested that through blockchain technology, intermediaries between advertisers and users can be reduced or eliminated, thus increasing the level of satisfaction of both parties [7]. Similarly, it can also provide trust and transparency for advertisers, reduce transaction costs, increase efficiency, simplify contracts, and improve invoicing processes [8].

In the digital advertising and marketing sector, the inadequacy of legal regulations and deficiencies in the existing processes and models used have led to a number of problems recorded in reports. Studies have revealed problems such as injustice in income distribution, inability to reach the right target audience, irregularities in privacy and data processing, failure to return the investment made by institutions at the desired rate, users' use of ad blocking and deception software, compulsory trust in intermediaries, etc. For these reasons, a new system based on mutual trust between consumers and institutions in the sector, where all processes can be monitored by peers and privacy is at the forefront, is required [6,9-11]. A new business model using blockchain technology can benefit from the digital advertising industry. A new model using blockchain technology can solve some problems in the industry by eliminating different disadvantages for all parties in the digital advertising industry.

The digital advertising industry, valued at \$209.7 billion globally in 2022 [1], is a cornerstone of modern marketing. Yet, it grapples with systemic inefficiencies: opaque transaction tracking, privacy breaches, and intermediary dominance [5,6]. These issues result in misaligned incentives, fraudulent activities like click fraud, and limited user control over personal data, undermining trust and cost-effectiveness [11].

This study proposes "Ex-Mad," a blockchain-based decentralized marketing framework designed to resolve these challenges. Ex-Mad targets three core problems:

- 1) Opacity in transaction tracking,
- 2) Inequitable reward distribution,
- 3) Inefficient targeting due to intermediary reliance.

Leveraging blockchain's immutability [12], smart contracts' automation [13], and IPFS's distributed storage, Ex-Mad introduces an experience-based system where users earn rewards for completing tasks aligned with their expertise, tracked via a reputation score. It is necessary to clarify these fundamental technologies in the context of marketing. Smart contracts can be defined as digital agreements that automatically enforce predetermined rules or procedures (such as campaign rules, 'payment is only made when an ad is viewed') without the need for an intermediary, and that execute themselves without external intervention. Similarly, IPFS (Interplanetary File System) functions as a decentralized hard drive, enabling large media files, such as video ads, to be stored securely and inexpensively across the network, rather than congesting the blockchain ledger. Together, these technologies stand out as being positioned to eliminate the role of traditional advertising intermediaries. This paper details Ex-Mad's architecture, implementation options, and evaluation, demonstrating its potential to advance digital marketing by bridging gaps in transparency, equity, and efficiency identified in prior studies [9,14].

The remainder of the article is organized as follows. The following section provides preliminary information about the research problem, blockchain technology, and digital marketing. In Section 3, we propose a model built on blockchain technology for improving advertising processes and designing the prototype architecture. Section 4 presents an evaluation by comparing the model's results on the test network with the model's real-life data. The last section provides conclusions regarding this study and information about future studies.

2. BACKGROUND AND RELATED WORK

2.1. Current Status and Challenges of Digital Marketing

Marketing involves researching consumer needs and designing new products that consumers want to buy. The process involves including consumers to establish more productive relationships [15]. Traditional marketing methods include email, social networks, and websites, while digital marketing utilizes digital tools and channels [16]. The fundamental concept of marketing is change [17]. Marketing science must continue to evolve and adapt to changes in technology and trends to keep up with sellers and consumers. The emergence of digital marketing in the 1990s marked a significant step in this evolution [18].

Digital marketing is an interface through which customers interact with sellers' products and services. This interface acts as a connection between customers and companies. Customers can access the interface through social networks, search engines, e-commerce channels, and mobile devices. Meanwhile, sellers use marketing tools such as email, search engine marketing, marketing research, and digital marketing to reach potential customers through these channels. In his study on digital marketing, Wymbs referred to this interaction interface as 'Digital Touch Points' [19]. With technology constantly evolving, these contact points are subject to change, and the obstacles to establishing a mutually sustainable relationship between stakeholders are increasing.

Issues that arise between stakeholders during marketing, such as privacy violations, irrelevant and excessive advertisements, and insufficient interaction, are biased toward the customer. Companies often face criticism of various issues. To address these

problems, many companies are now adopting more human-centric approaches, often resorting to personalized advertising. This differentiates traditional marketing channels and enables practical and real-time measurements.

Existing marketing platforms make money by selling the personal data they collect from their users to third parties in return for making the services accessible, the costs between the customer and the seller, the ad blocker market that develops day by day as a result of users being exposed to many advertisements they do not want, automatic click tricks carried out through programs, etc. This also brings disadvantageous situations, such as harming all stakeholders in the sector.

While the most fundamental element of a company's focus to achieve sustainable competitive advantage is its customers, the company uses reliable intermediaries to communicate and interact with its customers. This process prevents the interaction between advertisers and users from being fast, complete, accurate, and cost-effective. Blockchain technology can come into play at this point and eliminate the intermediaries between advertisers and users [7].

Although blockchain technology has been shown to have many essential effects in the field of marketing and advertising, such as reducing transaction costs, creating secure and verifiable transactions, and, most importantly, enabling real-time micropayments, it has not given enough importance [20]. With this technology, customers can decide how to participate in a marketing campaign, what information they will share without coercion, and how long they will participate in advertising and marketing activities. At the same time, satisfaction levels can be kept at a high level with direct payment due to their activities. In return, sellers will have high value-added marketing opportunities by directly reaching customers with the profile and value they want without being connected to any intermediary. For all these reasons, it is essential to research blockchain technology in a sector-specific manner and carry out innovative studies.

2.2. Other Recommendations

Marketing is not a field of science that can be evaluated by relying only on numerical values. It can be said that it is difficult to achieve success without implementation in the field and without measuring the effects on the targeted audience, that is, without putting theory into practice. For this reason, when implementable changes occur in the sector, it is necessary to review the theories, make changes if necessary, and even replace the old ones with new ones. Companies should benefit from new technological developments to create a competitive advantage, increase brand value, and gain new markets and customers [21].

Since there may not be any change in the results if newly emerging and developing technologies are used with traditional business models, new technologies must bring about business model changes at the business level. New business models can contribute to the development of the current economic structure of a business by improving its product and service quality [22]. Today, digital marketing is a rapidly growing sector. Blockchain technology is another technology that has quickly developed in parallel with this growth. As research on blockchain technology increases, there are new application areas, leading to constructive changes in these areas, and studies are being carried out specifically in digital marketing. It stands out as a technology candidate for making changes in the sector.

Academic studies investigating the benefits that can be obtained from the use of blockchain technology in marketing activities are still limited. However, in some theoretical studies, ideas have been proposed to prioritize some study areas of this technology in the sector [20,23-25].

Blockchain technology has the potential to revolutionize digital marketing by enhancing transparency, efficiency, and trust across various aspects. First, immutable records on the blockchain can increase transparency, allowing for more accurate tracking of ad impressions, clicks, and campaign performance, thereby reducing discrepancies and fraud [14,26]. Second, blockchain can enable cheaper advertisements by streamlining processes and eliminating intermediaries. Disintermediation can result in reduced costs for advertisers and publishers. Additionally, blockchain can provide alternative payment gateways for the creator economy, enabling content creators to receive micropayments directly from viewers, bypassing traditional platforms that take a cut [27].

Blockchain-based identity management solutions can help combat ad fraud and clickjacking issues, ensuring that marketing budgets are spent effectively [9]. They also allow for a better understanding of audience affiliation, enabling marketers to target specific demographics more precisely and avoid irrelevant ad placements. Smart contracts on the blockchain can be used for customized delivery of ads and automated campaign optimization [28]. Self-executing contracts can trigger actions based on predefined parameters, ensuring efficient ad delivery and budget allocation. Blockchain provides a transparent, efficient, and trustworthy framework for building a digital marketing ecosystem.

Blockchain technology ultimately provides greater transparency for consumers. This technology allows consumers to know who owns their data and how to access it. This will allow marketers to have more data for their campaigns. Although marketers may have to pay users to obtain the information they want, the data obtained in this way will be accurate and usable.

2.3. Identification of the Current Digital Marketing System and Its Weaknesses

The advertising and marketing sector comprises numerous intermediary institutions, each catering to different user groups. To reach the intended audience, campaigns are delivered through these intermediaries. Companies invest significant resources in these institutions to promote their brands online to the desired user groups. Companies increasingly transfer resources to enable quick and effective processing of user feedback, real-time campaign measurements, and planning for subsequent campaigns. This approach is a more cost-effective alternative to user research [29].

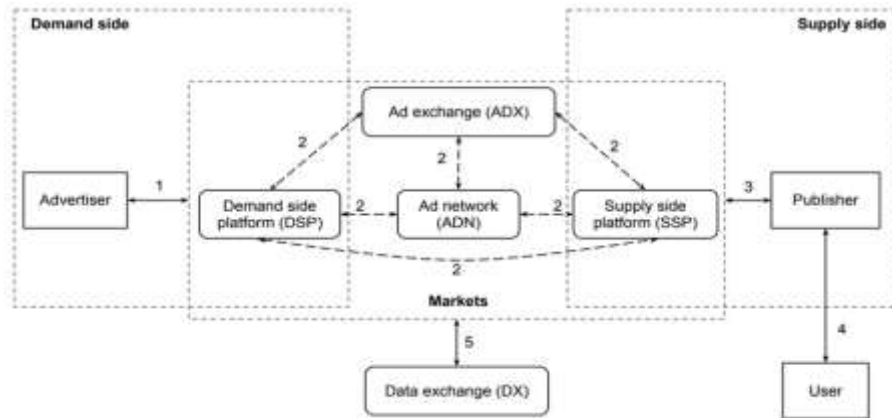


Figure 1. Advertising exchange system diagram

The digital advertising and marketing ecosystem has become increasingly complex due to new industry needs and developments in the digital environment. Various key players, such as ad networks, demand-side platforms, supply-side platforms, and ad exchanges, have joined the ecosystem to meet these needs. This system is called the 'platform-based ecosystem' in the literature [30]. Figure 1 illustrates the current functioning of this ecosystem [31].

The process starts with an advertiser identifying the requirements, such as budget, target audience, and duration, and submitting a request to the DSP to run the advertising campaign. When end-users visit a webpage, their location, contact information, trackable preferences, etc., are transferred to the publisher. If there is a priority contract, the publisher meets this demand directly. Otherwise, it sends advertising requests to supply-side platforms. A request for a quote is generated by supply-side platforms and sent to all demand-side platforms. The instant auction exchange determines the winning bid by summing the bid prices. The winning demand platform is notified of the decision and provided with information. This process is completed quickly, and the winning ad is displayed to the user who visits the web page [32].

Although the system may appear perfect, irregularities and instabilities may occur. One negative aspect experienced in digital platform-based ecosystems is that the players who make up the ecosystem, particularly the end-users who are the target audience, become weaker against the large players and other intermediaries who control the ecosystem. As the system expanded, issues arose with the distribution of budget shares, resulting in a system rarely benefiting end users. These problems have affected the perspective of published advertisements and marketing styles from the user's point of view. Additionally, similar issues can be observed on the intermediary side, including numerical inconsistencies and untraceable campaign results.

As a result, centralized digital marketing systems suffer from the following issues in particular:

- **Lack of Transparency:** Intermediaries obscure data flows, leaving advertisers dependent on unverifiable metrics [4].
- **Unequal Incentives:** While end users who receive data supporting campaigns do not directly benefit, intermediaries also receive incentives from end users [11].
- **Targeting Inefficiency:** Incompatible intermediary targets lead to suboptimal audience reach, leading to wasted budgets [9].

Ex-Mad is designed to address these issues by decentralizing all of these processes, providing transparent data processing via blockchain, fair rewards via smart contracts, and precise targeting based on user expertise and reputation.

3. PROPOSED SOLUTION: A DECENTRALIZED MARKETING NETWORK FOCUSED ON BLOCKCHAIN-BASED USER EXPERIENCE

The proposed model aims to overcome three prominent digital advertising and marketing challenges by leveraging blockchain technology and smart contracts. The model consists of three main components: Users (Companies and End Users), Blockchain, and IPFS.

Blockchain technology aims to create a transparent and reliable database for the digital advertising and marketing industry. It is designed to eliminate intermediaries and provide transparency between advertisers and users, thus addressing issues related to trust and transparency in the industry. The proposed model uses the open data structure provided by blockchain technology to ensure transparency and trust within the system.

The framework also aims to ensure that end users can perform most of their actions within the system. This could include receiving certain income based on their interactions within the system. By integrating blockchain and smart contracts, the model aims to facilitate seamless and efficient distribution of benefits to end users based on their activities or contributions on the platform. Another critical aspect of the proposed framework is enabling companies to access the targeted user database through advertising and marketing campaigns. Using blockchain technology and smart contracts, the model aims to facilitate effective targeting of specific demographic groups and ensure that marketing efforts reach the target audience precisely.

The blockchain component of the framework uses smart contracts to interact with users and manage tasks and interactions within the application. The Interplanetary File System (IPFS) stores task-related files due to their large size and distributed nature. IPFS creates a cryptographic hash for each uploaded file, allowing efficient storage and access without adding additional load to the blockchain.

3.1. Implementation of an experience-based decentralized marketing and advertising model

The Ex-Mad framework is designed to operate on Ethereum Virtual Machine (EVM)-compatible blockchains, enabling flexibility in deployment to balance cost, scalability, transaction speed, and decentralization. The choice of blockchain significantly impacts Ex-Mad's performance, particularly given its reliance on smart contracts for task management, reputation tracking, and reward distribution, as well as the Interplanetary File System (IPFS) for storing campaign-related files. Below, we evaluate four EVM-compatible blockchains Ethereum, Avalanche, Binance Smart Chain (BSC), and Polygon based on their technical characteristics, alignment with Ex-Mad's requirements, and trade-offs. This analysis ensures that Ex-Mad can be tailored to various use cases, from small-scale pilots to large-scale marketing campaigns involving thousands of users. The Ex-Mad framework is designed to operate on Ethereum Virtual Machine (EVM)-compatible blockchains, enabling flexibility in deployment to balance cost, scalability, transaction speed, and decentralization. The choice of blockchain significantly impacts Ex-Mad's performance, particularly given its reliance on smart contracts for task management, reputation tracking, and reward distribution, as well as the Interplanetary File System (IPFS) for storing campaign-related files. Below, we evaluate four EVM-compatible blockchains Ethereum, Avalanche, Binance Smart Chain (BSC), and Polygon based on their technical characteristics, alignment with Ex-Mad's requirements, and trade-offs. This analysis ensures that Ex-Mad can be tailored to various use cases, from small-scale pilots to large-scale marketing campaigns involving thousands of users.

3.1.1. Ethereum

Ethereum is the most established EVM-compatible blockchain, known for its robust security, extensive developer ecosystem, and widespread adoption [13]. It uses a Proof-of-Stake (PoS) consensus mechanism since the 2022 Merge, improving energy efficiency while maintaining decentralization. For Ex-Mad, Ethereum provides a reliable platform for deploying smart contracts that manage tasks, verify user interactions, and update reputation scores. Its immutable ledger ensures transparency, critical for advertisers seeking auditable campaign data.

However, Ethereum's high transaction costs, known as gas fees, pose a challenge. Testing on the Sepolia testnet (March 2024, ETH at \$3,480) showed costs of \$12.18 for contract deployment, \$1.36 for task creation, and \$1.32 for task completion. For a campaign with 2,500 users, this translates to a per-user cost of \$1.33, significantly lower than traditional methods (\$2.80/user) but higher than other blockchains. Additionally, Ethereum's transaction throughput (15 transactions per second, tx/s) can lead to congestion during high-demand campaigns, potentially delaying task completions or reward distributions.

Ethereum is ideal for prototyping and small-to-medium campaigns where security and trust are paramount, such as high-value brand campaigns requiring indisputable transparency. Its mature ecosystem, including tools like Remix and Metamask, simplifies development and user onboarding. However, for large-scale deployments with thousands of micro-transactions, cost and scalability limitations may necessitate alternatives.

3.1.2. Avalanche

Avalanche is a high-performance EVM-compatible blockchain designed for scalability and low latency [33]. It uses a unique consensus protocol combining Proof-of-Stake and a directed acyclic graph (DAG) structure, achieving sub-second transaction finality and a throughput of up to 4,500 tx/s. Gas fees are significantly lower than Ethereum's, typically ranging from \$0.01 to \$0.05 per transaction, depending on network load.

For Ex-Mad, Avalanche's speed and cost efficiency make it suitable for campaigns requiring rapid task processing, such as real-time user surveys or interactive ad engagements. Estimated costs for a 2,500-user campaign are \$125.15 total (\$0.05/user), offering a 98.2% savings compared to traditional methods. Avalanche's C-Chain, which is EVM-compatible, supports Ex-Mad's smart contracts without modification, while its scalability ensures consistent performance under heavy transaction loads. Additionally, Avalanche's eco-friendly consensus aligns with brands prioritizing sustainability in their marketing strategies.

Avalanche is well-suited for large-scale, high-frequency campaigns where low costs and fast transaction confirmation are critical. Its ability to handle thousands of simultaneous user interactions makes it ideal for viral marketing campaigns or time-sensitive promotions. However, its smaller developer community compared to Ethereum may limit access to advanced tools or integrations.

3.1.3. Binance Smart Chain (BSC)

Binance Smart Chain (BSC) is an EVM-compatible blockchain optimized for low-cost transactions and high throughput (100 tx/s). It employs a Proof-of-Authority (PoA) variant of PoS, where a limited number of validators process transactions, resulting in gas fees as low as \$0.01 per transaction. For a 2,500-user Ex-Mad campaign, estimated costs are ~\$25.03 total (\$0.01/user), yielding a 99.6% savings over traditional methods.

BSC's low fees make it attractive for cost-sensitive campaigns like microtask-based marketing (e.g., social media engagements). EVM compatibility enables seamless deployment of Ex-Mad's smart contracts, and its integration with Metamask simplifies user access. The system also stands out for its speed and scalability. However, BSC's reliance on fewer validators than other chains raises concerns about centralization [34]. This could undermine Ex-Mad's goal of building trust through decentralization and discourage advertisers from prioritizing fully decentralized systems.

BSC is optimal for budget-conscious campaigns targeting broad audiences with frequent, low-value transactions. It excels in scenarios where cost minimization is critical, such as grassroots marketing or campaigns in developing markets. However, its centralization risks make it less suitable for applications requiring maximum trust, such as high-stakes corporate campaigns.

3.1.4. Polygon

Polygon, an Ethereum Layer-2 scaling solution, operates as an EVM-compatible sidechain with exceptionally low fees (\$0.001-\$0.01 per transaction) and high throughput (up to 65,000 tx/s). By batching transactions and settling them on Ethereum's mainnet, Polygon combines cost efficiency with Ethereum's security. For Ex-Mad, estimated costs for a 2,500-user campaign are ~\$25.03 total (\$0.01/user), matching BSC's savings of 99.6%. Polygon's fast confirmation times and scalability make it ideal for handling large volumes of task completions and reputation updates.

Polygon's tight integration with Ethereum's ecosystem allows Ex-Mad to leverage tools like Etherscan and Metamask while benefiting from lower costs. Its growing adoption in decentralized applications (dApps) ensures robust support for future enhancements, such as cross-chain interoperability. However, as a Layer-2 solution, Polygon introduces slight complexity in transaction settlement, which may require additional user education.

Polygon is the most versatile option for Ex-Mad, balancing cost, speed, and decentralization. It is ideal for both large-scale campaigns and iterative pilots, particularly for brands seeking Ethereum's security without its high fees. Its scalability supports Ex-Mad's long-term vision of handling millions of users across global marketing campaigns.

3.2. Comparative Analysis

The choice of blockchain platform depends on the Ex-Mad deployment goals and specific requirements. A detailed comparison of the four blockchain platforms evaluated for Ex-Mad—covering transaction costs, transaction speed, scalability, and decentralization—is presented in Table 1.

- Security and Trust: Ethereum excels for high-value campaigns where transparency is non-negotiable.
- Cost Efficiency: BSC and Polygon minimize expenses, ideal for micro-transaction-heavy campaigns.
- Scalability and Speed: Avalanche and Polygon handle high transaction volumes, supporting viral or real-time campaigns.
- Ecosystem Support: Ethereum and Polygon benefit from mature tools, easing development and adoption.

Table 1. Blockchain platform comparison for Ex-Mad deployment

Blockchain	Avg. Fee (USD)	Tx Speed	Scalability	Decentralization
Ethereum	1.32-12.18	15 tx/s	Moderate	High
Avalanche	0.01-0.05	4,500 tx/s	High	High
BSC	0.01	100 tx/s	High	Moderate
Polygon	0.001-0.01	65,000 tx/s	Very High	High

3.3. Strategic Considerations

For Ex-Mad's prototype, Ethereum was chosen due to its robust tooling and developer familiarity, as demonstrated in Sepolia testnet experiments. However, for production, Polygon or Avalanche are recommended for their cost and scalability advantages. A hybrid approach—using Ethereum for high-security tasks (e.g., contract deployment) and Polygon for user interactions—could optimize performance. Future iterations may explore cross-chain solutions, leveraging bridges to combine Ethereum's trust with Polygon's efficiency, aligning with emerging trends in multi-chain ecosystems [24].

3.4. Technical Implementation

The Ex-Mad framework leverages blockchain technology, smart contracts, and the Interplanetary File System (IPFS) to create a decentralized, transparent, and user-centric digital marketing ecosystem. This section details the technical implementation, focusing on the system's workflow, smart contract architecture, and integration with distributed storage. By addressing the limitations of centralized marketing platforms such as opacity, intermediary reliance, and inequitable reward distribution [4,11], Ex-Mad introduces an experience-based task completion model underpinned by a reputation mechanism. The implementation is designed to ensure scalability, security, and efficiency, aligning with the principles of decentralized systems articulated in foundational blockchain literature [12,13].

4. SYSTEM WORKFLOW

Ex-Mad's operational workflow is structured to facilitate seamless interactions between advertisers (task creators) and end-users (task completers) without intermediaries, a critical departure from traditional platform-based ecosystems. The Ex-Mad sequence diagram, shown as Figure 2, provides a high-level overview of these interactions, showcasing the roles of the User, Company, Reviewer, Blockchain, and the Ex-Mad smart contract in orchestrating a decentralized advertising ecosystem. The process comprises four primary stages, each leveraging blockchain and IPFS to ensure transparency, immutability, and scalability, attributes that are critical for building trust in decentralized systems.

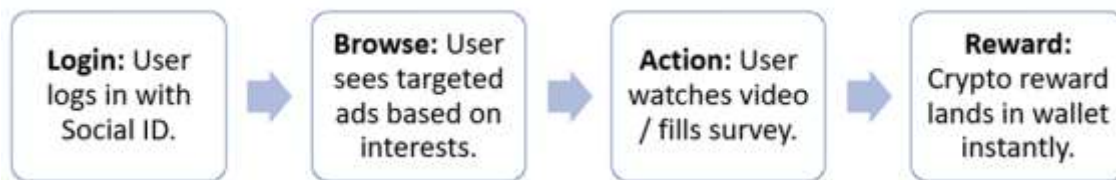


Figure 2. Simplified User Process Diagram

Figure X shows the simplified user process within Ex-Mad. First, the user logs in, interacts with an advertising campaign related to their interests, and automatically qualifies for a reward directly after verification and processing, bypassing complex technical steps.

4.1. User Authentication and Onboarding

Users connect to the Ex-Mad system, as illustrated in the sequence diagram, through the `registerUser()` function. This process leverages Metamask, a browser-based wallet that interfaces with EVM-compatible blockchains (e.g., Ethereum's Sepolia Testnet). Metamask authenticates users by providing a public-private key pair, enabling secure interaction with smart contracts. This aligns with blockchain-based identity management solutions that enhance user control over data [9]. The confirmation received post-registration signifies the successful onboarding of the user into the Ex-Mad ecosystem, ensuring their eligibility to participate in subsequent tasks.

The system, which requires a Web3 wallet (such as MetaMask), presents an adoption barrier for end-users without technical expertise. In future versions, integration of Web3 social login screens will allow users to interact with the system using their existing login screens (such as Google or social media accounts). A wallet infrastructure running in the background will be able to transparently manage blockchain transactions. This approach will significantly reduce challenges for inexperienced general internet users.

4.2. Task Creation and File Storage

Advertisers initiate tasks (e.g., surveys, product reviews, social media engagements) by defining parameters such as task type, reward, and eligibility criteria (e.g., minimum reputation score). As the sequence diagram indicates, task creation is triggered by the `createReviewTask(ipfsHash, ...)` function, which includes the IPFS hash of the task-related files. These files, such as multimedia campaign assets, are uploaded to IPFS, a decentralized storage protocol that generates a cryptographic hash for each file [35]. The hash is recorded on the blockchain, ensuring efficient storage without overloading the ledger. A deposit, paid in the blockchain's native cryptocurrency (e.g., ETH), is locked in the smart contract to incentivize task completion. This process leverages IPFS's content-addressable storage to ensure data integrity and availability.

4.3. Task Execution and Verification

End-users browse available tasks through the Ex-Mad interface, selecting those matching their expertise or interests. Upon completing a task, the sequence diagram illustrates the `submitReview(taskId, reviewIpfsHash)` function being invoked, where the `reviewIpfsHash` represents the location of the completed review on IPFS. The smart contract verifies compliance with predefined criteria, such as task format or user reputation. This automated verification reduces fraud risks, a significant issue in centralized advertising [26].

4.4. Reward Distribution and Reputation Update

Upon successful verification, the sequence diagram shows that the smart contract transfers the reward. The Ex-Mad system releases the deposit to the task completer and updates both parties' reputation scores on-chain. The `getUserInfo(userAddress)` function enables users and authorized entities to query the blockchain for user-specific information, including reputation and completed tasks. The reputation mechanism, inspired by trust models in decentralized systems [7], prioritizes reliable users for future tasks, enhancing system integrity and user engagement. The transparency and immutability provided by the blockchain ensure a fair and auditable reward distribution process [36].

Ex-Mad aims to create a more transparent, secure, and efficient ecosystem for marketing and advertising compared to traditional, centralized platforms, particularly by leveraging the unique features of smart contracts.

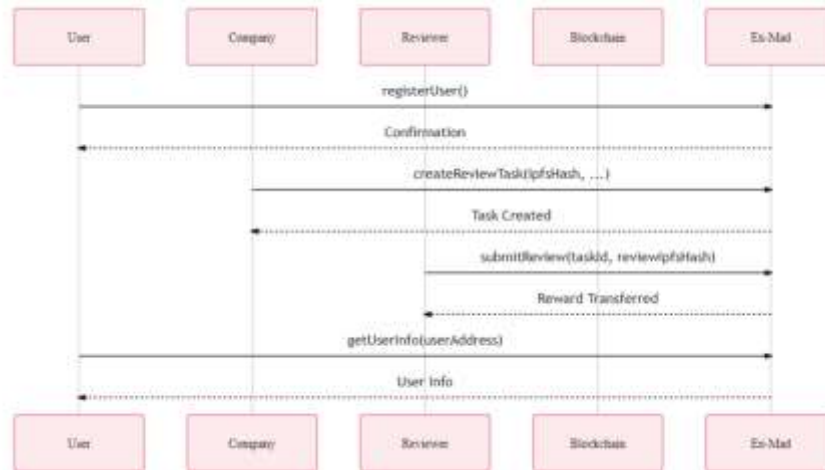


Figure 3. The Ex-Mad sequence diagram

4.5. Smart Contract Architecture

The core of Ex-Mad's functionality is implemented through a series of smart contracts written in Solidity, a high-level, object-oriented programming language specifically designed for EVM-compatible blockchains [37]. These smart contracts automate task management, verification processes, and the distribution of rewards, effectively removing the need for trusted intermediaries and fostering a decentralized ecosystem. The architecture incorporates several innovative features aimed at ensuring transparency, security, and efficiency.

4.5.1. Task Struct and Immutable Data Storage

Each task within the Ex-Mad platform is meticulously represented as a ReviewTask struct, which encapsulates critical information such as the creator's address, an IPFS hash linking to task metadata, the predetermined reward amount, the maximum number of reviewers allowed, and the task's completion status. This structured approach, shown as Figure 4, ensures that all essential task-related data is immutably stored on the blockchain, providing a transparent and verifiable record of each task's lifecycle [13].

By leveraging IPFS for storing task metadata, Ex-Mad ensures that large files and complex data associated with each task are efficiently managed without bloating the blockchain [35]. The immutability of the blockchain, combined with decentralized storage solutions like IPFS, provides a robust foundation for data integrity and accessibility.

A critical concern in blockchain adoption is the handling of sensitive user data on a public ledger. Ex-Mad addresses this by employing a privacy-preserving hybrid architecture. Personally Identifiable Information (PII) is never stored on-chain. Instead, the blockchain only records non-identifiable reputation scores and cryptographic hashes of interaction data. Detailed user profiles are stored in encrypted off-chain storage (on local devices or secure private databases). This design allows the system to remain compliant with data protection regulations (such as GDPR), as users retain full sovereignty over their private data while still participating in the transparent economy.

```

Algorithm 1 Register User
Require: userAddress: Address of the user to register
Ensure: User is registered with initial reputation
    RegisterUser(userAddress)
1: if users[userAddress].isRegistered == true then
2:   throw "User already registered"
3: end if
4: users[userAddress].isRegistered ← true
5: users[userAddress].reputation ← 10
6: users[userAddress].completedTasks ← 0
7: emit UserRegistered(userAddress)

```

Figure 4. Register user algorithm

4.5.2. Reputation System and User Management

A core component of Ex-Mad is its reputation system, which relies on user registration and activity tracking to maintain a reliable environment. New users are registered via the registerUser function, which initializes their profile, while their reputation is dynamically adjusted based on their participation and success in completing tasks.

4.5.3. Event Logging and Transparent Audit Trails

To ensure transparency and verifiability, the Ex-Mad smart contracts are designed to emit events for all key actions and state changes within the platform. These events include user registration, task creation, and review submission. By emitting these events, the smart contracts enable the creation of a transparent audit trail that can be easily tracked and verified using tools like Etherscan.

4.5.4. Task Creation and Review Process

The Ex-Mad platform facilitates a streamlined workflow for decentralized marketing and advertising. Central to this process are the `createReviewTask` and `submitReview` functions, which govern the creation of tasks and the submission of reviews, respectively.

4.5.5. Task Creation

A company or user initiates the process by creating a review task and specifying the associated reward. The task details, including the metadata IPFS hash and the maximum number of reviewers, are stored on the blockchain using the `createReviewTask` function.

```

Algorithm 2 Create Review Task
Require: companyAddress: Address of company, ipfsHash: IPFS hash,
maxReviewers: Maximum reviewers, rewardAmount: Payment amount
Ensure: New review task is created
    CreateReviewTask(companyAddress, ipfsHash, maxReviewers, rewardAmount)
1: if users[companyAddress].isRegistered = false then
2:   throw "User not registered"
3: end if
4: if rewardAmount ≤ 0 then
5:   throw "Reward must be greater than 0"
6: end if
7: if maxReviewers ≤ 0 then
8:   throw "Max reviewers must be greater than 0"
9: end if
10: taskId ← taskCounter
11: taskCounter ← taskCounter + 1
12: reviewTasks[taskId].company ← companyAddress
13: reviewTasks[taskId].ipfsHash ← ipfsHash
14: reviewTasks[taskId].maxReviewers ← maxReviewers
15: reviewTasks[taskId].currentReviewers ← 0
16: reviewTasks[taskId].reward ← rewardAmount
17: reviewTasks[taskId].isCompleted ← false
18: emit ReviewTaskCreated(companyAddress, taskId, rewardAmount)

```

Figure 5. Create review task algorithm

This function, as shown in Figure 5, ensures that all necessary task parameters are properly recorded on the blockchain, creating a verifiable record of the task's creation.

4.5.6. Review Submission

Registered reviewers can then submit their reviews for the assigned task. To submit a review, a user must have sufficient reputation and must not have already reviewed the task. The logic for this process is shown in Figure 6.

4.5.7. User Registration and Information Retrieval

To participate in the Ex-Mad ecosystem, users must first register using the `registerUser` function. This process, as shown in Figure 7, sets up the user's initial parameters and allows them to begin participating in tasks.

Additionally, the `getUserInfo` function allows external contracts and users to query information regarding a user's registration status, reputation, and completed tasks. This facilitates transparency and allows other parts of the system to verify user credentials.

With its aforementioned features and unique workflow, Ex-Mad can provide a solid foundation for a transparent, secure, and efficient ecosystem for decentralized marketing and advertising. This innovative approach not only leverages the inherent advantages of blockchain technology but also contributes to the evolution of decentralized autonomous organizations (DAOs) in the marketing industry, providing a new framework for value creation and exchange [38]. The use of Solidity and the EVM guarantees stability and seamless compatibility with the Ethereum blockchain, aligning with current trends in blockchain-based solutions [39]. In addition, the incentive mechanisms and transparent governance built into the smart contract design foster a self-regulating community, addressing challenges related to trust and participation often observed in traditional advertising models [41].

Algorithm 3 Submit Review

Require: *reviewerAddress*: Address of reviewer, *taskId*: Task identifier,
reviewIpfsHash: Review IPFS hash

Ensure: Review is submitted and reviewer is rewarded
 SubmitReview(*reviewerAddress*, *taskId*, *reviewIpfsHash*)

```

1: if users[reviewerAddress].isRegistered = false then
2:   throw "User not registered"
3: end if
4: if users[reviewerAddress].reputation < 10 then
5:   throw "Insufficient reputation"
6: end if
7: if taskId ≥ taskCounter then
8:   throw "Task does not exist"
9: end if
10: if reviewTasks[taskId].isCompleted = true then
11:   throw "Task already completed"
12: end if
13: if reviewTasks[taskId].hasReviewed[reviewerAddress] = true then
14:   throw "Already reviewed this task"
15: end if
16: reviewTasks[taskId].hasReviewed[reviewerAddress] ← true
17: reviewTasks[taskId].currentReviewers ← reviewTasks[taskId].currentReviewers +
  1
18: individualReward ← reviewTasks[taskId].reward / reviewTasks[taskId].maxReviewers
19: transfer individualReward to reviewerAddress
20: users[reviewerAddress].reputation ← users[reviewerAddress].reputation + 5
21: users[reviewerAddress].completedTasks ← users[reviewerAddress].completedTasks +
  1
22: emit ReviewSubmitted(reviewerAddress, taskId)
23: if reviewTasks[taskId].currentReviewers ≥ reviewTasks[taskId].maxReviewers
  then
24:   reviewTasks[taskId].isCompleted ← true
25: end if

```

Figure 6. Submit review algorithm

Algorithm 4 Get User Information

Require: *userAddress*: Address of the user to query

Ensure: Returns user registration status, reputation, and completed tasks
 GetUserInfo(*userAddress*)

```

1: user ← users[userAddress]
2: return (user.isRegistered, user.reputation, user.completedTasks)

```

Figure 7. User information algorithm

5. ANALYSIS OF IMPLEMENTATION AND RESULTS

The contract was distributed on a network in this section, and status tests were performed. The results of the tests were interpreted and documented, indicating the contributors to the literature. It is important to note that a smart contract cannot be altered once it is deployed to the blockchain network. However, a 'self-destruction' piece of code can be added to render the smart contract unusable under certain conditions. During the development phase of a smart contract, test networks are used to avoid the constant payment of 'gas' for deployment and repeated transaction testing. The gas values in the test networks and the main network do not differ significantly. For these reasons, the Sepolia testnet, which closely resembles the main Ethereum (mainnet) network in terms of usage, was used to distribute the smart contract and perform other transactions.

The cost calculation for publishing a smart contract on the Ethereum blockchain network using the EIP-1559 protocol is as follows:

Total cost = Unit of gas used * (block base fee + priority fee (Tip)) [41].

To expedite network transactions, users may pay a tip to the miner, which moves their transaction to the front of the line during block creation. In addition, it is possible to receive a refund if the actual fee is lower by setting a maximum fee for transactions. For example, suppose Person A transfers 1 ETH to Person B, with a current block base fee of 200 Gwei, a 20 Gwei tip to increase priority, and a gas price of 21000 Gwei for basic transactions. For example, suppose Person A transfers 1 ETH to Person B, with a current block base fee of 200 Gwei, a 20 Gwei tip to increase priority, and a gas price of 21000 Gwei for basic transactions. For example, suppose Person A transfers 1 ETH to Person B, with a current block base fee of 200 Gwei, a 20 Gwei tip to increase priority, and a gas price of 21000 Gwei for basic transactions. The following operations can be performed: The cost calculation is as follows: $21,000 * (200 + 20) = 4,620,000$ Gwei, equivalent to 0.00462 ETH. When person A sends 1 ETH to person B,

1.00462 ETH is deducted from person A's account, and 1 ETH is transferred to person B's account. The values in between will be shared as miner and block-burning fees in the system.

5.1. Deploy Contract

Upon loading the smart contract with the aforementioned information, a screenshot from the Etherscan website, where transactions on the Ethereum Network can be tracked, is displayed in Figure 8[42].

From:	0xD643a5F0d817a02ed96B8CEB390daA7396dc6c84
To:	0x933d2f7f728145233ec39e412651b4a29a1f4ba6 Created
Value:	0 ETH (\$0.00)
Transaction Fee:	0.003502254525683053 ETH (\$0.00)
Gas Price:	1.500000011 Gwei (0.000000001500000011 ETH)

Figure 8. Screenshot of the smart contract transaction process

The figure shows that approximately 0.0035 Ether (equivalent to 3,500,000 GWei) was paid to send the smart contract, prepared on March 29, 2024, to the test network. On that day, the ETH price was approximately \$12.18. Monetary values were obtained from the CoinMarketCap database. The values given in the study are subject to change and these changes can be tracked on the referenced CoinMarketCap website [43].

5.2. Create Task

Figure 9 provides details on the task creation process. To create a task, approximately $3480 * 0.00039$ ETH, equivalent to \$1.36, is needed. The 'From' address initiates the task creation process, while the 'To' address publishes the contract on the network, as shown in the figure.

From:	0xD643a5F0d817a02ed96B8CEB390daA7396dc6c84
To:	0x933D2f7F728145233eC39E412651b4A29a1F4ba6
Value:	0 ETH (\$0.00)
Transaction Fee:	0.000388132502846305 ETH (\$0.00)
Gas Price:	1.500000011 Gwei (0.000000001500000011 ETH)

Figure 8.Screenshot of the completed task

5.3. Complete Task/Send Payment

Figure 10 shows the operations and associated user-based costs required to complete a task. The figure highlights that the task creator is distinct from the task performer, but the contract user address remains the same. This is due to a control and verification process that prevents the task creator from performing the task themselves. Although each transaction incurs a cost in the smart contract, the necessary verification checks are also a crucial part of the architectural structure. When the cost in the contract is examined, the approximate cost to a user of performing a task is $0.00038 \text{ ETH} * 3480 \$ = 1.32 \$$.

From:	0xbe5777435e5144f8c2048Ee7ACb6A28DD0aF96E4
To:	0x933D2f7F728145233eC39E412651b4A29a1F4ba6
Value:	0 ETH (\$0.00)
Transaction Fee:	0.000384417002819058 ETH (\$0.00)
Gas Price:	1.500000011 Gwei (0.000000001500000011 ETH)

Figure 9.Screenshot of the completed task

Table 2 below presents the costs incurred in conducting the tests required to implement the proposed system. These costs include using surveys, evaluations, questions and answers, video advertisements, print media, and field studies using tools.

Table 2. Test costs for transactions made in the ex-mad system

Transaction Type	ETH Per Transaction	USD Per Transaction
Distributing a contract by uploading it to the network	0,003500 ETH	12,18 USD
Creation of a new task specified in the contract	0,000388 ETH	1,36 USD
Performing a task specified in the contract	0,000384 ETH	1,32 USD

A survey budget was requested from various research companies for use in our study. The budgets received were for an average of 2,000 to 5,000 people. The prices were converted to dollar exchange rates using the Central Bank of the Republic of Turkey exchange rates for that day. The amount per person was then determined. In the bids submitted by the companies, it was observed that the lowest unit price per person was 1.9 USD, and the highest unit price was 3.7 USD for the research to be carried out.

The costs were calculated by using the same application on the blockchain-based system we developed. Transactions performed on the test network were performed for a single user. Subsequently, the calculation was repeated using the average sample value of 2,500 individuals. If the cost calculated for a single person is wanted to be calculated for 2500 users, the costs calculated for creating the task and distributing the contract to the network will remain the same; only the task execution value will be recalculated for 2500 users. In this case, the calculation for 2500 users will be as follows:

$$12.18 + 1.36 + (1.32 * 2500) = \$3,313.54$$

When the total cost found is shared among 2500 users, the average price per person for all transactions is $3,313.54 / 2500 = \$1.33$.

5.4. Evaluation of the Results

The test values resulting from the basic measurements were approximately \$1.33 per person. Research companies give this value as \$2.8 on average for similar studies. Compared to real-life transactions:

$$\text{Difference: } 2.8 - 1.33 = \$1.47$$

$$\text{Cost savings percentage: } (1.47/2.8) \times 100\% = 52.5\%$$

By distributing the desired portion to the users as a reward based on the difference amount, an automatic loyalty mechanism is created within the system. The tested tasks are distributed randomly in real life, and the feedback does not provide the targeted amount of information about the product. The proposed system architecture facilitates access to very valuable and monetary information, as it ensures that data are received in accordance with the target that the customer focuses on today, when big data is now considered the most important resource.

5.5. Limitations and Scalability

Although our prototype tests were conducted on the Ethereum Sepolia testnet to validate the functional logic, tests were also performed for different network preferences, considering that Ethereum's Mainnet transaction throughput (approximately 15 transactions/sec) can create bottlenecks for high-volume, real-time bidding scenarios typical of digital advertising. In the production environment, the use of high-throughput Layer 2 solutions (such as Polygon) or high-performance chains (such as Avalanche, as discussed in Table 1) is essential. Since these networks can process thousands of transactions per second, they can ensure that ad delivery delays remain negligible and user rewards are processed almost instantly. Therefore, they can offer a seamless user experience under heavy ad loads. The continuously evolving blockchain technologies will be evaluated in future studies to determine the optimal network selection.

6. CONCLUSION

This study presents a new system architecture that prioritizes reliability, fair distribution, and transparency using blockchain technology in the digital advertising and marketing industry. The system aims to enhance existing processes, such as reliable outcome evaluation, fair reward distribution, and cost efficiency, by utilizing smart contracts. Furthermore, a reputation-based evaluation mechanism has been designed to ensure appropriate participation in areas of expertise and to prevent malicious users from participating. Simulation tests demonstrate that the system is reliable, providing end users with fair economic benefits and ensuring that all stakeholders can view transactions transparently.

As the number of samples increases, the marketing costs incurred by traditional methods (such as face-to-face, telephone, and computer methods) increase directly. On the other hand, the cost of tasks incurred in the new system architecture we designed,

which uses a smart contract, does not increase in proportion to the number of people. This provides a cost advantage inversely proportional to the number of samples.

One of the most important findings of this study is the demonstration of a 52.5% cost reduction compared to traditional centralized intermediaries. This significant saving is not just theoretical; it stems from the elimination of "intermediary fees" typically charged by DSPs, SSPs, and advertising exchanges. Ex-Mad, a system that uses smart contracts to route budgets directly from advertisers to end-users, has produced results proving that decentralized architectures can be both more transparent and more economically advantageous. This efficiency will provide a strong incentive for advertisers to transition from opaque legacy platforms to blockchain-based solutions.

As a result, blockchain technology can help reduce costs by providing transparency and security in the advertising and marketing industry with targeted and correct applications.

Authors' Contributions

In this study, authors contributed equally to the study.

Competing Interests

The authors declare that they have no conflict of interest.

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Availability of supporting data

This published article and its supplementary information files include all data generated or analyzed during this study.

Ethical Approval

Not Applicable

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